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Progress Report for the Period  
26 April 1984 through 8 November 1984

Prediction of the Dynamic Response of Risers and Cables

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Submitted to:

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## Introduction

The purpose of this work is to develop models for the prediction of non-lockin response of long flexible cylinders to flow-induced lift and drag forces. The statement of work included two specific research tasks.

1. Develop a lift coefficient prediction model, using the wake oscillator concept. This concept has been used to estimate the lift coefficient from cylinder response for the lockin case. Wake oscillator model equations can be utilized if it is assumed that the cylinder response is a Gaussian random process under non-lockin conditions. Evaluation of previous experimental data confirms this assumption.
2. Investigate the non-linear correlation between in-line and cross-flow vibration. Use bi-spectral analysis techniques to investigate the properties of a quadratic relationship between lift and drag excitation. Develop a non-lockin random process model of the lift and drag excitation on long cylinders which includes quadratic properties revealed during the course of the research.

The work is nearing completion with final manuscript preparation well underway. The nominal completion date of the project is 30 November 1984. An extension with no additional funds has been requested to 31 December 1984.

A brief status report on both items in the statement of work is given below.

### The Wake Oscillator Model for the Non-Lockin Case

This work is essentially complete. A draft of a manuscript on the subject has been previously sent to you. Though we were able to obtain solutions for the non-lockin case, using the concept of the wake oscillator, we feel the wake oscillator model for non-lockin conditions has very limited usefulness and we do not intend to pursue its application. The quadratic system models proposed in Task 2 have much greater promise and are far less computationally cumbersome to work with. The results of the bi-spectrum work indicate that in-line and cross-flow vibration are highly correlated but with a non-linear relationship. Therefore, proper use of wake oscillator models would require the use of separate in-line and cross-flow models which are non-linearly correlated. This would be very difficult to do.

### Bi-Spectrum Analysis and Quadratic Systems Identification

The basic research has just been completed in the form of a Ph.D. dissertation by Jen-Yi Jong. The principal results are presented below.

1. In-line and cross-flow vibration response are not independent processes for either lockin or non-lockin cases. The results of bi-spectral analysis indicate that these geometrically perpendicular responses are quadratically correlated to one another.
2. Non-linear correlations higher than second order are negligible in both lockin and non-lockin conditions.

3. Quadratic system models have been identified that can be used to predict in-line motions given the cross-flow motions as inputs.

The bi-spectrum analysis results and the quadratic system identification work are being presented in two manuscripts which are presently in preliminary draft form.

On a related subject, the research work for NADC on the vibration of very long cables in sheared flows has been completed, and the Ph.D. dissertation based on that research will be available very soon.